

ART 34 AMDT

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WHAT IS CLAIMED IS:

1. A radio frequency (RF) up-converter with reduced local oscillator leakage, for modulating an input signal $x(t)$, comprising:
- a synthesizer for generating mixing signals ϕ_1 and ϕ_2 which vary irregularly over time, where $\phi_1 * \phi_2$ has significant power at the frequency of a local oscillator signal being emulated, and neither ϕ_1 nor ϕ_2 has significant power at the frequency of said local oscillator signal being emulated;
 - a first mixer coupled to said synthesizer for mixing said input signal $x(t)$ with said mixing signal ϕ_1 to generate an output signal $x(t) \phi_1$; and
 - a second mixer coupled to said synthesizer and to the output of said first mixer for mixing said signal $x(t) \phi_1$ with said mixing signal ϕ_2 to generate an output signal $x(t) \phi_1 \phi_2$.
2. The radio frequency (RF) up-converter of claim 1 wherein said synthesizer further comprises:
- a synthesizer for generating mixing signals ϕ_1 and ϕ_2 , where $\phi_1 * \phi_1 * \phi_2$ does not have a significant amount of power within the bandwidth of said output signal $x(t) \phi_1 \phi_2$.
3. The radio frequency (RF) up-converter of claim 2 wherein said synthesizer further comprises:
- a synthesizer for generating mixing signals ϕ_1 and ϕ_2 , where $\phi_2 * \phi_2$ does not have a significant amount of power within the bandwidth of said output signal $x(t) \phi_1 \phi_2$.
4. The converter of claim 3, further comprising:
- a closed loop error correction circuit.
5. The radio frequency (RF) up-converter of claim 4, wherein said closed loop error correction circuit further comprises:
- an error level measurement circuit for measuring an error in said output signal $x(t) \phi_1 \phi_2$; and
 - a time-varying signal modification circuit for modifying a parameter of one of said mixing signals ϕ_1 and ϕ_2 to minimize said error level.

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6. The radio frequency (RF) up-converter of claim 5, wherein said error level measurement circuit comprises a power measurement.
7. The radio frequency (RF) up-converter of claim 5, wherein said error level measurement circuit comprises a voltage measurement.
8. The radio frequency (RF) up-converter of claim 5, wherein said error level measurement circuit comprises a current measurement.
9. The radio frequency (RF) up-converter of claim 5, wherein said modified parameter is the phase delay of one of said mixing signals ϕ_1 and ϕ_2 .
10. The radio frequency (RF) up-converter of claim 5, wherein said modified parameter is the fall or rise time of one of said mixing signals ϕ_1 and ϕ_2 .
11. The radio frequency (RF) up-converter of claim 5, wherein said modified parameter includes both the phase delay and the fall or rise time of one of said mixing signals ϕ_1 and ϕ_2 .
12. The radio frequency (RF) up-converter of claim 3 wherein said synthesizer further comprises:
a synthesizer for generating mixing signals ϕ_1 and ϕ_2 , where said mixing signals ϕ_1 and ϕ_2 can change with time in order to reduce errors.
13. The radio frequency (RF) up-converter of claim 3, further comprising:
a DC offset correction circuit.
14. The radio frequency (RF) up-converter of claim 13, wherein said DC offset correction circuit comprises:
a DC offset generating circuit for generating a DC offset voltage;
a summer for adding said DC offset voltage to an output of one of said mixers; and
a DC error level measurement circuit for modifying the level of said DC offset voltage to minimize error level.

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15. The radio frequency (RF) up-converter of claim 14, wherein said DC error level measurement circuit comprises a power measurement circuit.
 16. The radio frequency (RF) up-converter of claim 14, wherein said DC error level measurement circuit comprises a voltage measurement circuit.
 17. The radio frequency (RF) up-converter of claim 14, wherein said DC error level measurement circuit comprises a current measurement circuit.
 18. The radio frequency (RF) up-converter of claim 1, further comprising:
a filter for removing unwanted signal components.
 19. The radio frequency (RF) up-converter of claim 18, where said filter comprises:
a filter for removing unwanted signal components from said $x(t) \phi_1$ signal.
 20. The radio frequency (RF) up-converter of claim 1, wherein said mixing signals ϕ_1 and ϕ_2 are random.
 21. The radio frequency (RF) up-converter of claim 1, wherein said mixing signals ϕ_1 and ϕ_2 are pseudo-random.
 22. The radio frequency (RF) up-converter of claim 1, wherein said synthesizer uses a single time base to generate both mixing signals ϕ_1 and ϕ_2 .
 23. The radio frequency (RF) up-converter of claim 1, wherein said mixing signals ϕ_1 and ϕ_2 are digital waveforms.
 24. The radio frequency (RF) up-converter of claim 1, wherein said mixing signals ϕ_1 and ϕ_2 are square waveforms.
 25. The radio frequency (RF) up-converter of claim 3, further comprising:
a local oscillator coupled to said synthesizer for providing a periodic signal having a frequency that is an integral multiple of the frequency of said local oscillator signal being emulated.

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26. The radio frequency (RF) up-converter of claim 4, wherein said closed loop error correction circuit comprises a digital signal processor (DSP).
27. The radio frequency (RF) up-converter of claim 4, wherein said closed loop error correction circuit comprises analogue components.
28. The radio frequency (RF) up-converter of claim 4, wherein said closed loop error correction circuit further comprises:
an error level measurement circuit for measuring an error in said output signal $x(t)$ ϕ_1 ; and
a time-varying signal modification circuit for modifying a parameter of one of said mixing signals ϕ_1 and ϕ_2 to minimize said error level.
29. The radio frequency (RF) up-converter of claim 1, where said synthesizer uses different patterns to generate signals ϕ_1 and ϕ_2 .
30. A method of modulating a baseband signal $x(t)$ comprising the steps of:
generating mixing signals ϕ_1 and ϕ_2 which vary irregularly over time, where $\phi_1 \neq \phi_2$ has significant power at the frequency of a local oscillator signal being emulated, and neither ϕ_1 nor ϕ_2 has significant power at the frequency of said local oscillator signal being emulated;
mixing said input signal $x(t)$ with said mixing signal ϕ_1 to generate an output signal $x(t) \phi_1$; and
mixing said signal $x(t) \phi_1$ with said mixing signal ϕ_2 to generate an output signal $x(t) \phi_1 \phi_2$.
31. An integrated circuit comprising the radio frequency (RF) up-converter of any one of claims 1 - 29.
32. A computer readable memory medium, storing computer software code in a hardware development language for fabrication of an integrated circuit comprising the radio frequency (RF) up-converter of any one of claims 1 - 29.

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33. A computer data signal embodied in a carrier wave, said computer data signal comprising computer software code in a hardware development language for fabrication of an integrated circuit comprising the radio frequency (RF) up-converter of any one of claims 1 - 29.